

## **BALLISTIC ARMOR PANEL**

### **FIELD OF THE INVENTION**

This invention generally relates to ballistic armor panels of the type useful in protection of objects and equipment against small arms bullets and kinetic energy projectiles, i.e. fire arm rounds and projectiles artillery fragments and shrapnel. The invention is in particular concerned with a carrying board supporting a plurality of bodies.

### **BACKGROUND OF THE INVENTION**

Ballistic armor panels are utilized for a variety of protective missions, in particular for reducing hit-risk of objects such as vehicles, equipment, structures, etc. from small arms projectiles, kinetic energy penetrators and from fragments of explosive charges, bombs, etc. For that purpose, armor panels are applied to the objects, which armor panels should be capable of stopping a bullet or a projectile or a fragment of an explosive charge within an extremely short distance, i.e. the effective thickness of the ballistic armor panel.

A variety of armor panels are known, each typically comprising several layers of material holding a plurality of hard bodies typically made of ceramic material for effectively distributing the impact of a projectile, bullet, etc. Typically the ceramic bodies are bonded to the carrying layers by suitable adhesive materials.

One considerable disadvantage of heretofore known armor panels resides in that the carrying layers are not fitted for attaching directly to the object to be protected, whereby additional fixing means are required which are both heavy and somewhat cumbersome in assembly. A second disadvantage is the labor required for assembling protective panels of the aforementioned type. Evermore, the ceramic bodies are exposed and are thus vulnerable to mechanical damage and after a series of several hits they may brake and the ballistic panel may loose its effectiveness. In particular, the edges of the ceramic bodies are susceptible to damage and break easily, reducing the effectiveness of the armor panel.

It is thus an object of the present invention to provide a new and improved armor panel, which substantially reduces or overcomes the above drawbacks.

#### SUMMARY OF THE INVENTION

The present invention provides an improved ballistic armor panel for attaching to an object, the panel comprising a carrying board made of a hard material and formed with a plurality of adjoining through-going apertures, each aperture receiving a body made of a hard materiel and having a longitudinal axis coaxial with an axis of the respective aperture. Typically, the bodies are made of a ceramic material, such as, for example, alumna, silicone carbide, boron carbide, etc. The bodies may be made of a low density material although this is not a requirement.

Preferably, the bodies correspond in shape with the apertures of the board. Said bodies may be cylindrical or polygonal. By one specific design, where the bodies are polygonal, the openings of the carrying board form together a honey-comb like shape.

Preferably, in order to retain the bodies within the apertures and to reduce their susceptibility to breakage, the apertures are formed with an annular rim extending into the aperture and being essentially flush with a surface of the carrying board remote from the object.

According to a different embodiment, the apertures taper from a face of the carrying board facing the object.

The bodies may be also adhered within the apertures of the carrying board. They may also be adhered to a back layer of resilient material applied between the object and the carrying board. Such a layer may be made, for example, from laminates of ballistic fibers.

5 The carrying board may be formed with suitable bores for directly attaching to a surface of the object. Any of the apertures of the board may serve as a bore.

### BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting  
10 example only, with reference to the accompanying drawings, in which:

**Fig. 1** is perspective view, partially cut-out, of a ballistic armor panel according to a first embodiment of the present invention;

**Fig. 2** is a sectional view of a portion of a ballistic panel according to a modification of the invention, wherein the apertures are formed with an annular  
15 rim;

**Fig. 3** is a sectional view of a portion of a ballistic panel according to a still a modification of the invention, wherein the apertures taper;

**Fig. 4** is a sectional view illustrating a modification of the embodiment seen in Fig. 3A wherein the apertures taper and are formed with an annular rim;

**Fig. 5** is a sectional view illustrating a further application of the present invention, with a resilient back-layer provided at a back face of the carrier board;

**Fig. 6** is a perspective view, partially cut-out, of still a different embodiment of the invention.

### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

25 Attention is first directed to Fig. 1 of the drawings in which a ballistic panel 10 comprising a carrying board 12 made of a hard material such as, for example, steel, titanium, aluminum, composite materials, etc. The carrying board is formed with a plurality of apertures 16, which in the present example are

cylindrical. The apertures 16 may be machined or may be pre-molded, e.g. when the carrying board is made of cast material.

The thickness of the wall between adjoining apertures is between about 0.5 to 1 mm. However, this thickness may differ depending on different parameters such as type of materials and its mechanical properties, thickness of panel, etc.

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The carrying board 12 is formed with several bores 20, for connecting the panel to an object by bolts 22, etc. However, any one of the apertures 16 may also serve for attaching the board to the object (not shown. The object may be a structure, a vehicle, etc.) with possible use of different adapters.

10 A plurality of cylindrical bodies 24, made of an essentially hard material e.g. hard ceramics such as alumina, boron carbide, silicone carbide, glass, etc. are received within the apertures 16. The bodies 24 are snugly received within the apertures 16 and their axial length does not exceed that of the apertures, whereby the bodies 24 do not project from a front face 30 of the carrying board 12.

15 In order to prevent the bodies 24 from spontaneously detaching from the carrying board 12, a bonding material may be applied between the walls of the bodies 24 and the apertures 16.

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According to one particular embodiment (not shown), the axial length of the bodies 24 is shorter than that of the apertures and the front faces 32 of the bodies are retracted so that they extend below the front face 30 of the carrying board, rendering the edges of the bodies less susceptible to external impact and to deterioration upon hitting by an external body thus reducing the damage of the of the bodies 24.

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25 Further attention is now directed to Fig. 2, wherein an armor panel 40 is attached to an object 42 by bolts 44. The apertures 46 of the carrying member 48 are formed with an annular rim 50 at a front end thereof, essentially flush with the front face 54. This arrangement is useful both for retaining the bodies 56 within the apertures 46 as well as for preventing deterioration of the edges of the front face 58 of the body 56.

In Fig. 3 the carrying board **60** is formed with a plurality of apertures **62** tapering from a wide opening at a rear face facing the object (not shown) and a narrower opening at the front face **64**. This arrangement ensures that the bodies **66** do not disengage from the apertures of the carrying board.

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5 In the embodiment of Fig. 4 the carrying board **68** comprises tapering apertures **70** as in the embodiment of Fig. 3A, with the addition that each aperture is formed with an annular rim **72** as in the embodiment of Fig. 2, whereby the bodies **74** supported in such apertures are shorter than those of Fig. 3 and are thus more protected.

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10 Fig. 5 represents still a further embodiment in which a ballistic panel **80**, which is similar to the embodiment of Fig. 1, (although any other of the previous embodiments may be selected). In the present embodiment there is provided a thin layer of flexible material **82** (such as a resilient material, Kevlar™, Dyneema™, fiberglass, laminate of ballistic fibers, etc.) adhered to the back face of the carrying board **84** by a layer of adhesive substance **86**, bonding the bodies **88** on the one hand, and providing some impact dampening on the other hand.

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15 In Fig. 6 there is shown a ballistic panel **98** formed with a plurality of polygonal apertures **100** (hexagonal in the specific embodiment, though any other polygonal shape will be suitable, e.g. triangular, square, heptagonal etc.) each fitted with a body **102** having a corresponding shape and retained as explained hereinbefore. Bolts **105** extend via edge apertures **103** and are fitted with washers **105**.

20 As will be appreciated by a versed person, only some preferred embodiments have been shown and described in the specification and drawings. However, it is to be understood that it is not intended thereby to limit the disclosure of the invention, but rather it is intended to cover all modifications and arrangements falling within the scope and the spirit of the present invention, *mutatis mutandis*.